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THESIS

AN ANALYSIS OF THE MANPOWER IMPACT OF UNMANNED AERIAL VEHICLES ON SUBSURFACE PLATFORMS

by

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March 2012

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13. ABSTRACT (maximum 200 words)

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A manpower analysis was conducted to identify requirements necessary for submarine launched UAV operations. Current surface launched UAV Navy Enlisted Classification (NEC) codes were used as a comparison for the analysis. Currently these NECs are only available to aviation source ratings. Analysis shows that there are several submarine specific ratings that have the same knowledge entry requirements as the aviation source ratings that are eligible to operate UAVs.

Furthermore, research showed that based on the simplicity of operation of Switchblade and ScanEagle, that no additional manpower requirements are necessary. Specifically, on all classes of submarines, Switchblade can be launched and flown with no additional watchstations manned, compared to a standard mission watchbill. Also, with ScanEagle, SSGN class submarines require no additional watchstanders once the UAV is launched, and airborne than would be required for a normal mission watchbill.

Incorporating UAVs into the arsenal of a submarine is a vital requirement that needs accomplished. This research recommends the creation of a specific NEC for the submarine force to identify UAV operators.

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AN ANALYSIS OF THE MANPOWER IMPACT OF UNMANNED AERIAL VEHICLES ON SUBSURFACE PLATFORMS

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TABLE OF CONTENTS

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LIST OF FIGURES

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LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

(AE) Aviation Electrician's Mate

(AEA) Auxiliary Electrician Aft

(AM) Aviation Structural Mechanic

(AMCM) Aviation Mine Countermeasure

(AMD) Activity Manpower Document

(AO) Assembly of Object

(AQD) Additional Qualification Designator

(AR) Arithmetic Reasoning

(AS) Aviation Support Equipment Technician

(AS_1) Auto and Shop Information

(AT) Aviation Electronic, Electrical and Computer Systems Technician

(ATPL) Navy Aeronautical Technical Publication library

(AWF) Naval Aircrewman Mechanical

(AWO) Naval Aircrewman Operator

(AWR) Naval Aircrewman Tactical Helicopter

(AWS) Naval Aircrewman Helicopter

(AWV) Naval Aircrewman Avionics

(AZ) Aviation Maintenance Administration

(CMS) Communication Material Security

(CNO) Chief of Naval Operations

(COI) Critical Operational Issue

(COW) Chief of the Watch

(CS) Culinary Specialists

(CS_1)	Coding Speed
(CSAR)	Combat Search and Rescue
(DCNO)	Deputy Chief of Naval Operations
(DoD)	Department of Defense
(EI)	Electronic Information
(ELINT)	Electronic Intelligence
(EM(NUC))	Electrician's Mate (Nuclear)
(EO/IR)	Electro Optical/Infrared
(ERS)	Engineroom Supervisor
(ES)	Electronic Support
(ESM)	Electronic Support Means
(ET)	Electronics Technician
(FT)	Fire Control Technician
(GAO)	Government Accounting Office
(GPS)	Global Positioning System
(GS)	General Science
(IFF/SIF)	Identification Friend or FOE/Selective Identification Feature
(IS)	Intelligence Specialists
(JOOD)	Junior Officer of the Deck
(JOOW)	Junior Officer of the Watch
(LAN)	Local Area Network
(LS(SS))	Logistics Specialists (Submarine)
(MAD)	Magnetic Anomaly Detection
(MC)	Mechanical Comprehension
(MEDEVAC)	Medical Evacuation

(MM(SS))	Machinist's Mate (Submarine)
(MMW)	Machinists Mate Weapons
(MT)	Missile Technician
(NALCOMIS)	Naval Aviation Logistics Command Management Information System
(NAMP)	Naval Aviation Maintenance Program
(NAVMAC)	Naval Manpower Analysis Center
(NEC)	Navy Enlisted Classification
(NEOCS)	Navy Enlisted Occupational Classification System
(NO)	Numerical Operations
(NOOCS)	Navy Officer Occupational Classification System
(NSW)	Naval Special Warfare
(NVD)	Night Vision Device
(OOD)	Officer of the Deck
(PC)	Paragraph Comprehension
(POE)	Projected Operational Environment
(ROC)	Required Operational Capability
(SAR)	Search and Rescue
(SMD)	Ship Manpower Document
(SOTHOC)	Submarine Over the Horizon Organic Capabilities
(SSN-21)	Seawolf Class Fast Attack Submarine
(SSN-688)	Los Angeles Class Fast Attack Submarine
(SSGN-726)	SSGN Class Submarine
(SSN-774)	Virginia Class Fast Attack Submarine
(STS)	Sonar Technician Submarines
(TDU)	Trash Disposal Unit

(TFFMS) Total Force Manpower Management System

(UAVs) Unmanned Aerial Vehicles

(UAS) Unmanned Aircraft System

(UUVs) Unmanned Underwater Vehicle

(UVs) Unmanned Vehicles

(VE) Sum of Word Knowledge and Paragraph Comprehension

(VERTREP) Vertical Replenishment

(W&B) Weight and Balance

(WK) Word Knowledge

(YN(SS)) Yeoman (Submarines)

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I. INTRODUCTION

A. AREA OF RESEARCH

This research analyzes the manpower requirements and manning implications for operating Unmanned Aerial Vehicles (UAVs) aboard submarine platforms. This research considers different manning possibilities, based on the results of different UAV testing that has occurred. As a baseline this research starts by examining requirements currently in place for other UAVs currently in use by the U.S. Navy. Analysis of manpower standards, UAV, and manpower requirements for different subsurface missions and watch section evolutions will be conducted. The principal objective of this research is to provide the U.S. Navy a recommended watch team structure for a submarine launched UAV and manpower implications for regularly including UAVs aboard subsurface platforms.

B. RESEARCH QUESTION

1. Primary Question

- What are the manpower requirements associated with deployment, operations, recovery and maintenance of UAVs onboard SSN/SSGNs?

C. DISCUSSION

Over the past two decades UAVs have proven invaluable to mission commanders. Two Northrop Grumman unmanned aircraft systems (UAS) are combat proven—the RQ-4 Global Hawk with approximately 24,000 combat hours in support of overseas contingency operations and the MQ-5B Hunter with more than 60,000 combat hours.[1] UAVs provide a safer and stealthier way by which to investigate or engage an enemy in multi-mission environments. UAVs allow a submarine to distance itself from the area of operations while collecting the mission critical information. The Government Accounting

[1] Northrop Grumman, "Hale Program Overview History and Accomplishments," Northrop Grumman, http://www.as.northropgrumman.com/by_capability/unmannedsystems/index.html (accessed 12/11, 2011).

Office (GAO) recently stated, "Moreover, UAVs are no longer an additional 'nice to have' capability; they are becoming essential to the services' ability to conduct modern warfare."[2]

Incorporation of UAVs onboard submarines is at an all-time high due to continuous mission dynamics and more recently terrorism. Naval aviation and surface communities have been incorporating UAVs on a regular basis for several years. While the submarine force has limited itself to Unmanned Underwater Vehicles (UUVs) the technology and capabilities have progressed and now warrant another element or capability that only UAVs can deliver.

An accurate identification of manpower requirements is necessary to examine how to effectively incorporate UAVs into the submarine fleet. The framework used in the aviation community for UAV operations will be used as a comparison and development of the manpower requirements. This analysis provides recommendations pertaining to manpower requirements for submarine launched UAVs, specifically the Switchblade.

D. BENEFITS OF STUDY

This study of subsurface launched UAV manpower requirements is essential in formalizing fleet implementation of this valuable technology. Formalizing the manpower and school requirements will allow a streamlined process for required manpower and schooling pertaining to subsurfaced launched UAVs.

E. SCOPE

The scope includes:

- An examination of previous research on UAV manpower requirements and utilization.
- A review of SSN/SSGN mission requirements and capabilities.

[2] U.S. General Accounting Office, "Major Management Issues Facing DOD's Development and Fielding Efforts." General Accounting Office, http://www.gao.gov/new.items/d04530t.pdf (accessed 12/12, 2011).

- A comparison of current UAV/UUV manpower with the submarine launched UAV.
- A determination required manpower necessary for UAV deployment from SSN/SSGN for specified missions.

F. METHODOLOGY

The methodology used in this thesis will be qualitative and will consist of the following steps:

- Conduct a literature review of UAV requirements and manpower requirements.
- Interview Submarine Development Squadron Twelve leadership to better understand the SSN/SSGN submarine mission requirements.
- Determine required manpower changes for UAV deployment on board SSN/SSGN submarine consistent with those currently being used on ship launched UAV.

G. THESIS ORGANIZATION

Chapter I: INTRODUCTION: This chapter establishes the primary purpose of this thesis and discusses the importance of UAVs to the submarine force. The primary and secondary questions are established.

Chapter II: LITERATURE REVIEW: This chapter provides a history of U.S. Navy uses of UAVs, reviews current manpower requirements, OPNAVINST 1000.16K, and officer and enlisted classification standards.

Chapter III: UNMANNED VEHICLES CAPABILITIES ON SSN/SSGN SUBMARINES: This chapter discusses concepts and requirements of UAV employment, UAV capabilities, and the future of submarine launched UAVs.

Chapter IV: MANPOWER REQUIREMENTS OF UAV DEPLOYMENT: This chapter incorporates submarine and UAV manpower structure with U.S. Navy standard workweek requirements necessary for integration into submarines.

Chapter V: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

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II. UNMANNED AERIAL VEHICLE BACKGROUND, USES, AND MANNING OVERVIEW

A. UNAMNNED AERIAL VEHICLE BACKGROUND AND USES

The U.S. Navy has been utilizing unmanned aerial vehicles (UAVs) since the early 1980s. The first UAVs used by the U.S. Navy were the Pioneers. During the Pioneer's initial deployments it provided reconnaissance in support of Marine landings and spotter services for naval surface fire support conducted by battleships.[3] The use of this UAV allowed for the units to have a more forward eye toward the enemy prior to walking into potential disaster.

Based on the dynamic change of the military and the downsizing of the number of ships and aircraft in the U.S. Navy, the UAV demand is continuing to grow. Maritime surveillance aircraft, specifically the SH-60 and the P-3C have been significantly reduced causing the decrease on an airframe hour per day basis as shown in Figure 1.

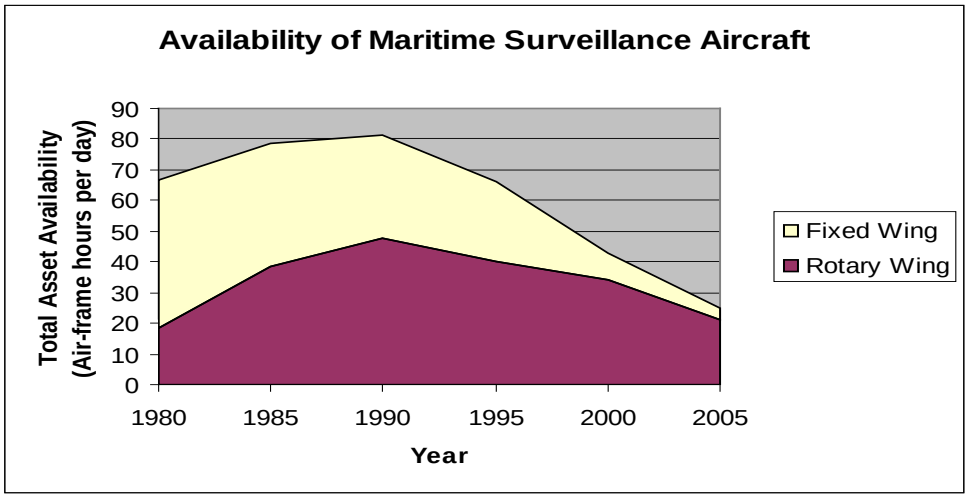

Figure 1. Availability of maritime surveillance assets has decreased over the years (From:[4])

[3] Department of the Navy, *Integration of Unmanned Vehicles into Maritime Missions TM 3-22-5-SW Navy Tactical Memorandum* (Washington, D.C.: Department of the Navy.

[4] Ibid.

With the continual decrease in maritime surveillance aircraft hours per day after year 2000, the expectations were for unmanned vehicles (UVs) platforms, with their sensors, to cover this requirement.[5] The need for continued surveillance with less manned assets was ever prevalent when in 2004 these shortages caused two deploying strike groups to call for, and receive, UVs to cover surveillance and reconnaissance requirements.[6] The failure to properly monitor areas of interest has forced the Department of Defense (DoD) to analyze and further invest in unmanned vehicle (UV) platforms.

B. MANPOWER OVERVIEW

1. Navy Total Force Manpower Policies Procedures OPNAV Instruction 1000.16K

The Chief of Naval Operations (CNO) delineates policy for the determination of manpower requirements in OPNAVINST 1000.16K. Manpower requirements are defined as, "the number of personnel required to perform the Navy's work and deliver the specified capability."[7] These requirements do not equate to actual personnel but to the space necessary for personnel assignment to a requirement. Specifically, these requirements are further evaluated and in accordance with the 1000.16K, "assigned qualifiers that define the duties, tasks, and functions to be performed and the specific skills and skill level required to perform the delineated functions."[8]

a. Required Operational Capability/Projected Operational Environment (ROC/POE)

Furthermore, fleet manpower requirements based on OPNAVINST C3501.2J create the ROC/POE document. The ROC provides, a precise definition of the

[5] Ibid.

[6] Ibid.

[7] Chief of Naval Operations, *OPNAV INSTRUCTION 1000.16K Navy Total Manpower Policies and Procedures* (Washington D.C.: Department of the Navy,[2007]).

[8] Ibid.

unit's mission statement[9] and the POE encompasses, a description of the specific operating environment in which the unit is expected to operate.[10] The ROC/POE is the main driver for the developing and establishing the Ship Manpower Document (SMD).

b. Ships Manpower Document (SMD)

SMDs are specific for each class of ship. Some classes of ship may have multiple SMDs depending on the differences in configurations. The SMD considers other important inputs than just the ROC/POE. For example, additional considerations may be: maintenance requirements, operational manning, utility requirements and the development of officer requirements to mention a few. Another essential element for developing the minimum number of requirements is the approved Navy Standard Workweek. The Navy Standard Workweek will be discussed in detail in Chapter IV.

C. NAVY ENLISTED OCCUPATIONAL CLASSIFICATION SYSTEM (NEOCS)

The driving force behind enlisted personnel assigned to a vessel, is the required skills necessary to operate equipment, stand assigned watches, and perform mission specific duties. The personnel abilities or attributes are tracked in a system of four character codes known as Navy Enlisted Classification (NEC) system contained in NAVPERS 18068F. Additionally, the NEC system facilitates management control over enlisted skills by identifying billets and personnel and enhancing efficient use of personnel in distribution and detailing.[11] The NEC system further allows special skills to be tracked via secondary NECs to ensure the right personnel are assigned to the right billet.

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[9] Ibid.

[10] Ibid.

[11] U.S. Navy, *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards*, Vol. I (Washington D.C.: , 2011), 1.

D. NAVY OFFICER OCCUPATIONAL CLASSIFICATION SYSTEM (NOOCS)

The NOOCS manual from NAVPERS 15839I, requires each officer to be assigned a four digit designator based on the training and job assignments from. These four digit codes provide, the primary administrative means for classifying, identifying, and documenting officer manpower resources.[12] Also, officers will be assigned an Additional Qualification Designation (AQD), which "dentifies additional qualifications and skills not included in the other code structures.[13] Officers onboard naval vessels exist for three reasons: [14]

1. Command Authority
2. Tactical Watch Stander
3. Special Skill/Knowledge

E. CURRENT SUBMARINE MANPOWER REQUIREMENTS

1. Los Angeles Class Fast Attack (SSN-688)

The SSN-688 class SMD identifies requirements for 15 officers and 139 enlisted personnel are required.[15] These personnel are divided amongst five departments:

1. Executive
2. Navigation/Operations
3. Combat Systems
4. Engineering
5. Supply

The Executive department has two officers and six enlisted personnel billeted. The Navigation/Operations department has three officers and 28 enlisted personnel

[12] U.S. Navy, *Manual of Navy Officer Manpower and Personnel Classifications*, Vol. I (Washington D.C.: , 2011), 3.

[13] Ibid., 3

[14] William D. Hatch, *Ship's Officer Staffing Guide: Report of Findings and Recommendations*, ed. Arthur Ohanian (Monterey, Ca: Naval Postgraduate School, 2003), 8.

[15] Navy Manpower Analysis Center, *SSN 688 Class Final Ship Manpower Document* (Millington, TN: , 2010).

billeted. The Combat Systems department has three officers and 35 enlisted personnel billeted. The Engineering department has six officers and 60 enlisted personnel billeted. The Supply department has one officer and 10 enlisted personnel billeted.

2. Virginia Class Fast Attack Submarine (SSN-774)

The SSN-774 class SMD identifies requirements for 15 officers and 117 enlisted personnel.[16] These personnel are divided amongst the Commander and five departments:

1. Executive
2. Navigation/Operations
3. Combat Systems,
4. Engineering
5. Supply.

The Executive department has one officer and six enlisted personnel billeted. The Navigation/Operations department has three officers and 21 enlisted personnel billeted. The Combat Systems department has three officers and 27 enlisted personnel billeted. The Engineering department has six officers and 53 enlisted personnel billeted. The Supply department has one officer and 10 enlisted personnel billeted.

3. Seawolf Class Fast Attack Submarine (SSN-21)

The SSN-21 class SMD identifies requirements for 15 officers and 138 enlisted personnel.[17] These personnel are divided amongst five departments:

1. Executive
2. Navigation/Operations
3. Combat Systems
4. Engineering
5. Supply.

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[16] Navy Manpower Analysis Center, *SSN 774 Class Final Ship Manpower Document* (Millington, TN: , 2010).

[17] Navy Manpower Analysis Center, *SSN 21 Class Final Ship Manpower Document* (Millington, TN: , 2009).

The Executive department has two officers and six enlisted personnel billeted. The Navigation/Operations department has three officers and 25 enlisted personnel billeted. The Combat Systems department has three officers and 35 enlisted personnel billeted. The Engineering department has six officers and 62 enlisted personnel billeted. The Supply department has one officer and 10 enlisted personnel billeted.

4. SSGN Class Submarine (SSGN-726)

The SSGN-726 SMD identifies requirements for 16 officers and 150 enlisted personnel are required.[18] These personnel are divided amongst five departments:

1. Executive
2. Navigation/Operations
3. Combat Systems
4. Engineering
5. Supply

The Executive department has two officers and six enlisted personnel billeted. The Navigation/Operations department has three officers and 22 enlisted personnel billeted. The Combat Systems department has four officers and 48 enlisted personnel billeted. The Engineering department has six officers and 62 enlisted personnel billeted. The Supply department has one officer and 12 enlisted personnel billeted.

[18] Navy Manpower Analysis Center, *SSGN 726 Class Final Ship Manpower Document* (Millington, TN: , 2010).

III. UNMANNED AERIAL VEHICLE CAPABILITIES ON SSN/SSGN SUBMARINES

A. CURRENT CONCEPTS AND REQUIREMENTS OF UNMANNED AERIAL VEHILCE EMPLOYMENT

1. Concepts

Unmanned vehicles (UVs) provide alternate means to gather data. According to TACMEMO 3-22-5-SW, "The goals of UV operations are: enhanced force detection, identification, tracking and reconnaissance of contacts in an area of interest."[19] The use of UVs is not intended to replace any sensor or tool in use; but extend the range of the current tools in use. UVs will be utilized to assist decision makers with many functions; specifically, searching, processing, locating, and collecting data and information.[20] These UVs allow for larger and more thorough searches of areas of interest as well as other dangerous missions further reducing the number of actual personnel subject to hostilities.

The continuous collection of information during missions is essential to all those onboard the vessel involved in data processing. Choosing to incorporate UVs—as a matter of routine—allows for more capability, and significantly lowers risk for the vessel and crew. In accordance with TACMEMO 3-22-5-SW, UV use is intended to accomplish the following six objectives:

> 1. Maximize sensor coverage, 2. Maximize likelihood of detecting actual contacts, 3. Minimize the time between detection and identification, 4. Minimize uncertainty regarding contact position and movement, 5. Minimize time latency between UV data collection and incorporation into the recognized maritime picture, 6. Maximize collection of priority intelligence.[21]

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[19] Department of the Navy, *Integration of Unmanned Vehicles into Maritime Missions TM 3-22-5-SW Navy Tactical Memorandum*, 1-2

[20] Ibid.

[21] Ibid.

All of these objectives are pertinent to a submarine's operating environment and mission requirement.

Submarines are continuously operating on an intelligence framework dependent on sensors or data gathered from another source. The incorporation of UVs, specifically Unmanned Aerial Vehicles (UAVs), would allow the submarine to collect information from a longer range while operating safer and increasing covert independence. TACMEMO 3-22-5-SW states, "Covering gaps left by a diminishing number of manned, tactical, ISR&T assets is one reason to use UVs."[22]

2. Requirements

When employing UAVs, submarines are required to maintain radio communications with them to receive the video feed which means maintaining periscope depth. This places the submarine in a more vulnerable environment with regards to detection by the adversary. The UAVs discussed in Chapter III, Section B are waypoint driven; the video feed is not recorded, therefore continuous monitoring is required. If a UAV's course must be altered during tasking, the submarine must be at periscope depth.

Another consideration for submarines is the operating environment. The Commanding Officer must evaluate weather, operating area and the capabilities of the enemy, to determine the suitability for establishing periscope depth for an extended period of time for launching, evaluating and either disposing or transferring operation of the UAV to another asset. Upon further analysis of the enemy, the TACMEMO highlights the following issues of concern: standoff ranges, traffic density, occurrence of COIs, and threat characteristics.[23]

During routine submarine operations, the boat is not concerned with atmospheric wind. Wind must be considered when operating a UAV at periscope depth. Based on the operating capabilities of the UAV, a head wind can render the UAV much less effective

[22] Ibid.

[23] Ibid.

and will decrease the range and speed that would be experienced in calm or milder conditions.

Precipitation and temperature will affect the UAV and its capabilities, performance, or endurance. Heavy rains can render the UAV useless, and cause the launching of the UAV to result in damage or destruction before any information can be obtained. In accordance with the TACMEMO, "Heavy precipitation can damage UAV power sources, and electrical and electronic systems. Heavy rainfall conditions (greater than 6mm/hr) can also ruin a UAV's propeller, causing it to fail or delaminate."[24] Additionally, the Commanding Officer has to consider air or water temperature prior to use. Below freezing temperatures can result in icing of the aircraft, which may render the UAV useless for its mission since many do not have de-icing capabilities.

B. CAPABILITIES OF UAVS

The submarine force has experimented with ScanEagle and Switchblade UAVs. Each UAV has desirability, but comes with cost or environmental restraints.

1. ScanEagle

Figure 2. ScanEagle (From: http://defense-update.com/products/s/scaneagle.htm)

[24] Ibid.

a. Background

ScanEagle is built by Insitu, a subsidiary of Boeing, and has been in use by U.S. Marine Corps since June of 2004.[25] The U.S. Navy established a contract to acquire the ScanEagle in April of 2005.[26] It was initially brought onboard for use during Operation Iraqi Freedom, as well as the Global War on Terror. ScanEagle has the capability to be launched and operated by ground forces or surface ships. Specifically, in May 2010, Boeing successfully tested a version of the UAV called ScanEagle Compressed Carriage.[27] This carriage allows it to be launched from another aircraft or a submarine.

b. Capabilities

ScanEagle has long term flight capabilities both of high altitude above 16,000 feet, or fly at a lower altitude for specific reconnaissance missions, which separate it from other UAVs. Its dimensions are, "four-feet long with a 10-foot wingspan, and can remain on station for more than 15 hours."[28] Additionally, it has the added ability to carry a payload of up to 6 kilograms.[29] Newer versions of ScanEagle have the ability to stay airborne for more than 28 hours while operating at speeds between 80–126 km/h with a cruise speed of 90km/h in level flight.[30] Its ability to adapt and change based on the mission and/or platform launched from or utilized by is very attractive.

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[25] Boeing, "Defense, Space & Security: ScanEagle," http://www.boeing.com/defense-space/military/scaneagle/index.html (accessed 02/28, 2012).

[26] Ibid.

[27] Chris Haddox, "Boeing Conducts Test Flight of ScanEagle Compressed Carriage," Boeing, http://boeing.mediaroom.com/index.php?s=43&item=1224 (accessed 02/29, 2012).

[28] Boeing, *Defense, Space & Security: ScanEagle*

[29] Defense Update, "ScanEagle: Unmanned Aerial System/Insitu/Boeing," Defense Update, http://defense-update.com/products/s/scaneagle.htm (accessed 02/29, 2012).

[30] Naval Technology, "ScanEagle, United States of America," Naval Technology, http://www.naval-technology.com/projects/scaneagle-uav/ (accessed 02/29, 2012).

c. Missions

According to Boeing, the primary mission of ScanEagle, was to loiter over trouble spots and provide intelligence, surveillance and reconnaissance (ISR) data or communications relay.[31] Initial capabilities included an inertially stabilized electro-optical or an infrared camera. The gimbaled camera allows the operator to easily track both stationary and moving targets, providing real-time intelligence.[32] Boeing has continued to evolve ScanEagle to allow flexibility in its uses. ScanEagle has a compartment in the center of the body referred to as the avionics bay. The avionics bay allows seamless integration of new payloads and sensors to meet emerging military requirements, and ensures the vehicle will be able to incorporate the latest technology as it becomes available.[33] Some examples of ScanEagle versatility is the ability to change sensor types allowing the ability to collect data on hostile threats including weapons of mass destruction and biological hazards.[34]

d. Operation

ScanEagle's current dimensions dictate that it is only capable of being launched from a Trident missile tube. The process requires the use of ScanEagle Compressed Carriage, and will use a sealed sub-scale container to launch from a Trident missile-launch tube. Once airborne, the container will open, starting the vehicle's deployment sequence.[35] Additionally, recovery is much more complicated and may require an additional asset such as a surface ship or a ground force component.

Once airborne, it flies from an operator console by means of satellites and operator inputs. Specifically, the control and navigation system provides the ScanEagle with waypoint navigation using differential GPS navigation, autonomous object tracking

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[31] Boeing, *Defense, Space & Security: ScanEagle*

[32] Ibid.

[33] Ibid.

[34] Defense Update, *ScanEagle: Unmanned Aerial System/Insitu/Boeing*

[35] Ibid.

and autonomous in-flight route mapping.[36] ScanEagle's ability to operate on a waypoint driven system allows for fewer people to be involved in operations. Traditionally, Boeing has utilized two operators, one operator sets waypoints for the airplane to follow, while another controls the payload—a camera mounted on a turret.[37] The technology utilized allows for precise flying and operation while providing the operators with the required information. Additionally, with technology developed and tested in June 2007, a single operator was able to control three aircraft simultaneously, taking the place of six people.[38]

Recovery is conducted using the SkyHook system. This system is designed such that, the UAV catches a rope hanging from a 50-foot high pole.[39] ScanEagle recovery is performed by a surface ship or in conjunction with a ground force unit.

2. Switchblade

Figure 3. Switchblade (From: http://www.avinc.com/uas/adc/switchblade/)

[36] Naval Technology, *ScanEagle, United States of America*

[37] Joe Pappalardo, "Flocking ScanEagles," *Air&Space Magazine*, 2007, .

[38] Ibid.

[39] Boeing, *Defense, Space & Security: ScanEagle*

a. Background

Switchblade is a small UAV built by AeroVironment nicknamed the magic bullet. In an effort with the Navy, AeroVironment has been heavily involved in the Submarine Over The Horizon Organic Capabilities (SOTHOC), and was awarded the sole contract for Switchblade in December, 2011.[40] Switchblade is capable of being operated from ground forces, surface ships, and submarines.

b. Capabilities

Switchblade is a small UAV with an operating altitude ranging from 15–200 meters.[41] It has an operating range of approximately 10,000m, with a flight endurance of 20–30 minutes.[42] Switchblade has a wingspan of 550mm, length of 365mm, weight of 1.3kg, and an operating speed of 55–80kts.[43]

c. Missions

Switchblade was designed to conduct intelligence, surveillance and reconnaissance on an over the horizon basis. This UAV has the ability to glide or propel itself via quiet electric propulsion, providing real time GPS coordinates and video for information gathering, targeting, or feature/object recognition.[44] Based on the size, construction, and dimensions of Switchblade, it is challenging for adversaries to detect or track it even at close range.

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[40] Defense Systems Staff, "Navy Readies Switchblade UAV for Submarine Missions," *DefenseSystems*, Dec 23, 2011, 2011, .

[41] Peter Harrigan, *Submarine Over the Horizon Organic Capabilities System Description* (Newport, RI: NAVSEA, 2011).

[42] Ibid.

[43] Ibid.

[44] AeroVironment, "UAS Advanced Development: Switchblade," http://www.avinc.com/uas/adc/switchblade/ (accessed 02/29, 2012).

d. Operation

Currently, Switchblade is submarine launched from the Trash Disposal Unit (TDU). Switchblade is placed in the launch canister which is ejected from the TDU, once a predetermined time has passed, the canister orients itself and floats to the surface. Once at the surface, the canister considers wind and sea states, then positions itself and launches Switchblade into the air. This process is shown in Figure 4.

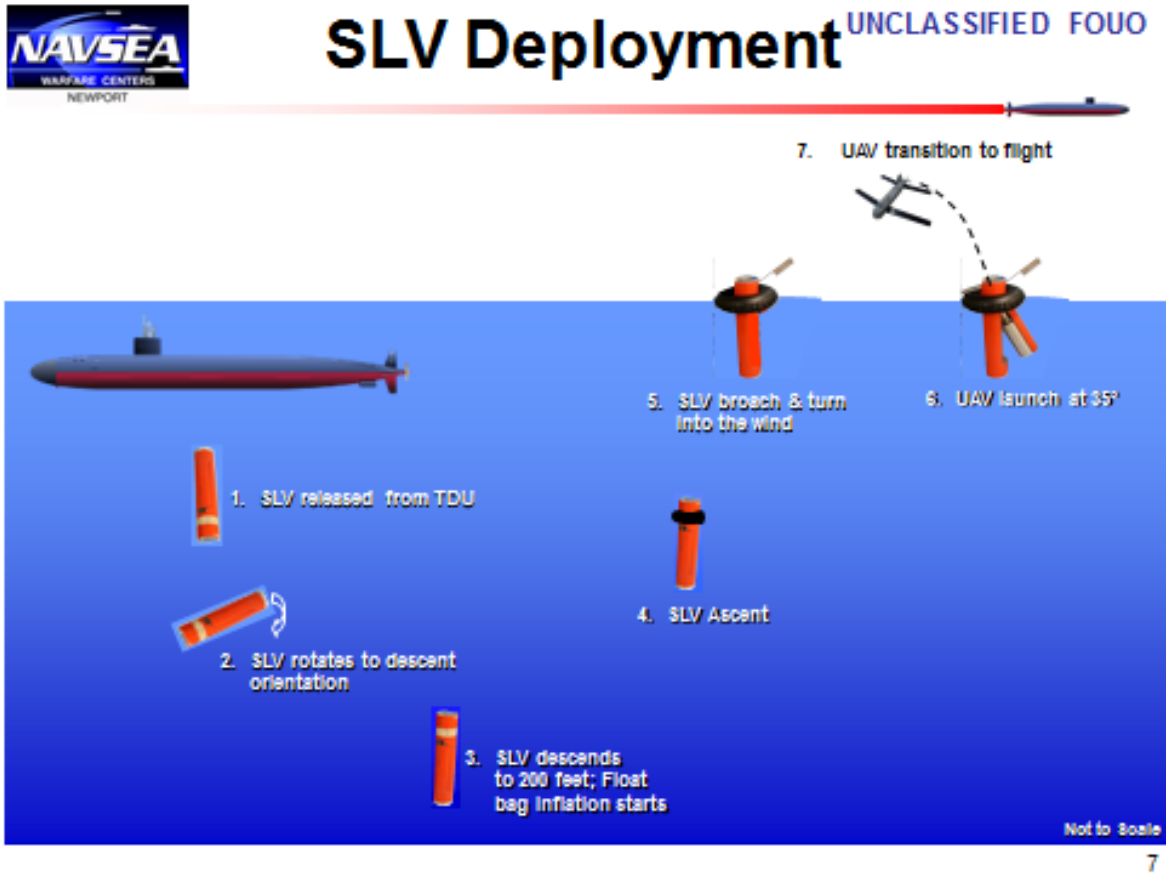

Figure 4. SLV Deployment (From: [45])

Switchblade operates on a waypoint driven system based on pre-programmed tracks. Typically, one operator is responsible for monitoring the track and one operator is responsible for monitoring the video feed being received. Switchblade,

[45] Harrigan, *Submarine Over the Horizon Organic Capabilities System Description*

unlike other UAVs, does not require a recovery method. Upon completion of its mission, it is designed to be crashed into the ocean or ground, destroying the UAV.

C. FUTURE OF SUBMARINE LAUNCHED UAVS

The submarine force is currently planning to test UAVs with other nations during an exercise in the summer of 2012. This test could demonstrate the effectiveness and usefulness of a UAV to the submarine force. The submarine force is considering many different options or possibilities for the future use of UAVs. In line with overall guidance, the submarine force will look at utilizing UAVs for force protection concerns. As Commander Tom Armstrong, Anti-Terrorism Force Protection Officer of Commander Naval Submarine Forces told Undersea Warfare magazine in 2005, "As our submarines often have to transit in and out of port through restricted waters, the ability to foresee any problems would be very beneficial from a force-protection standpoint."[46]

Additionally, the submarine force will use UAVs as a means by which to extend the visual range over the horizon, by using its ability to fly out ahead of the submarine to determine contact density, gather intelligence, or conduct surveillance operations. This type of capability allows the submarine to operate in a safer environment while still having the ability to gather the required information from potentially restricted areas. As described in TACMEMO 3-22-5-SW, "Cooperative search by electronic support (ES) or radar sensors enable use of UVs to conduct localization and identification, reducing uncertainty in the recognized maritime picture."[47] Demonstrating successful launch and control of UAVs is the next step to incorporating them onboard submarines.

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[46] Christina PO2 Shaw, "Submarine Force Test UAV Technology to Enhance Force Protection," *Undersea Warfare,* 2005, .

[47] Department of the Navy, *Integration of Unmanned Vehicles into Maritime Missions TM 3-22-5-SW Navy Tactical Memorandum*, 1-4

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IV. MANPOWER REQUIREMENTS OF UNMANNED AERIAL VEHICLE DEPLOYMENT

A. OVERVIEW OF MANPOWER PROCESS

1. Total Force Manpower Management

All U.S. Navy manpower requirements are driven from the OPNAVINST 1000.16K titled Navy Total Force Manpower Policies Procedures. This document dictates and drives the process by which manpower requirements, as well as authorizations and requirements are created and filled. The overall process is called Total Force Manpower Management and is defined as,

> The methodical process of determining, validating, and using manpower requirements to inform budget decision; prioritizing manpower authorizations based on available funding and personnel executability; and translating authorizations into a demand signal for personnel, training and education processes.[48]

Total Force manpower requirements depend on four things:

1. Fiscal constraints, which prevent buying all validated requirements.

2. Resource Sponsors and Enterprise Enablers, who make decisions on amount of workload to fund to maximize value within fiscal limits.

3. Enterprise/Enablers and Budget Submitting Offices, who make specific decisions on authorization based on skill and pay grade, occupational series, career group and pay band.

4. Chief of Naval Operations authorization requests for health and executability of Navy communities.

[48] Chief of Naval Operations, *OPNAV INSTRUCTION 1000.16K Navy Total Manpower Policies and Procedures*, 1-1

2. Manpower Requirement Determination

Manpower requirements drive the personnel needed to complete the U.S. Navy's mission. Defined manpower requirements are, "the number of personnel required to perform the Navy's work and deliver the specified capability."[49] A manpower requirement is commonly referred to as a manpower space. Manpower spaces are assigned qualifiers that define the duties, tasks and functions to be performed and the specific skills and skill level required to perform the delineated functions.[50] Manpower requirements fall into four categories:

1. Fleet Manpower requirements, which pertain to ship, squadrons, and other deployable units assigned personnel.

2. Shore Manpower requirements, which pertain to shore duty assigned personnel.

3. Individuals Account, which pertain to student, trainee, transient or hold and active duty Midshipmen status personnel.

4. Outside Navy requirements, which pertain to Combatant Commanders, defense agency, and Office of the Secretary of Defense assigned personnel.

This research will focus primarily on the Fleet manpower requirements and the effect of incorporating unmanned aerial vehicles onboard a submarine.

2. Manpower Authorizations

Once requirements are determined, the next step in the process is authorizations. Manpower authorizations are the actual number of personnel entitlement to provide the required capabilities for Fleet or operational units.[51] The key factor for a manpower requirement to become authorized depends on funding.

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[49] Ibid.

[50] Ibid.

[51] Ibid.

Funding quantity drives the number of requirements that are authorized. Manpower authorizations are driven by end strength as well, which is the total number of personnel allowed in the U.S. Navy at the end of the fiscal year.

B. FLEET MANPOWER REQUIREMENTS

Fleet manpower requirements fall under the responsibility of the Deputy Chief of Naval Operations (DCNO). He is responsible for planning, programming, managing, and executing Fleet manpower requirements.[52] The Naval Manpower Analysis Center (NAVMAC) coordinates with Type Commanders and Warfighting Enterprises to develop these requirements for the Chief of Naval operations (CNO).[53] The essential elements used to develop the Fleet manpower requirements are:

- Required Operational Capability/Projected Operational Environment (ROC/POE)
- DCNO approved staffing standards, especially Navy Standard Workweek
- Warfare publications
- Maintenance requirements
- Navy Maintenance and Material Management Systems
- Navy Training System Requirements, Acquisition, Key Performance Parameters, and Training Requirements Program Planning Management documents

Once the Fleet manpower requirements are determined they are used as one input into the Ship Manpower Document (SMD). The SMD also uses:[54]:

- ROC/POE
- Directed manpower requirements
- Operational Manning
- Preventive Maintenance
- Corrective Maintenance
- Facilities Maintenance

[52] Ibid.

[53] Ibid.

[54] Ibid.

- Application of approved staffing standards
- Workload measurement and analysis
- Utility tasking
- Allowances, Production Delay, Make Ready Put Away time
- Development of officer requirements
- Warfighting Enterprise, Type Commander, Enabler, and Activity review of draft documents

The SMD is the main document that lists all of the requirements for a specific class of ship. Once these requirements are generated, they are stored in the Total Force Manpower Management Systems (TFFMS). The requirements are analyzed, evaluated, and compared with funding, at which point some requirements are authorized. Requirements, authorizations, and end strength are evaluated to create billets that show up on an Activity Manpower Document (AMD).

C. NAVY STANDARD WORKWEEK

1. Background

The U.S. Navy standard workweek is a tool that evaluates all requirements and determines required enlisted personnel for a ship, squadron, or shore facility to allow for proper utilization of personnel. In accordance with OPNAVINST 1000.16K, the critical workweek input for sea duty units is based upon operational requirements under projected wartime conditions.[55] When considering the shore duty evaluations, they are based upon peacetime conditions. For the purpose of this research only the at-sea workweek will be discussed.

2. Description

The workweek is used as a guideline for sustained personnel utilization under projected wartime conditions and is not intended to reflect the limits of personnel

[55] Ibid.

endurance.[56] Actual work that occurs onboard will vary from the guidelines set forth in the workweek, as a result of mission or operational tempo. The dynamic environment that U.S. Navy ships operate in, makes it next to impossible to say only this much work can or will be done during any given day. Evolutions, drills, or actual casualties occur, and will cause a shift in the work requirements of the crew. These changing environments cause the workweek calculations to use a work averaging consideration. Work averaging considers the dynamic situations ships operate in and use the average weekly hours that will be expended on a monthly annual basis when performing calculations.[57]

The Afloat (Wartime) workweek calculation method is shown in Table 1.

Table 1. Afloat (Wartime)—Military Personnel Workweek (From:[58])

Analysis of Duty Hours		
Total hours available weekly		168.00
Less Non-Available Time:		
Sleep	(56.00)	
Messing	(14.00)	
Personal Needs	(14.00)	
Sunday	(3.00)	(87.00)
Scheduled On Duty Hours Per Week		81.00
Less:		
Training (Note 1)		(7.00)
Service diversion (Note 2)		(4.00)
Total Hours Available for Productive Work (Note 3)		**70.00**

Note 1: Training is an activity of an instructional nature, which contributes directly to combat readiness and deducts from the individual's capability to do productive work.
Note 2: Service diversion consists of actions required of military personnel by regulations or the nature of shipboard/staff routine
Note 3: For watchstanders, 56 hours is allocated to watch stations (8 hoursx7 days) (14 hours available for work in addition to 56 hours of watchstanding = 70 hours)

[56] Ibid.

[57] Ibid.

[58] Ibid.

Using the Navy Standard workweek combined with the ship requirements for each division, a minimum number of enlisted manpower requirements are generated. The generated requirements represent the minimum number of manpower requirements necessary to staff the activity to fully perform its wartime mission.[59]

D. UNMANNED AERIAL VEHICLE (UAV) MANPOWER STRUCTURE

1. Current Navy Enlisted Classification (NEC) and Rate Description Pertaining to UAVs

Currently, the Navy has four NECs pertaining to UAV operators. Obtaining any UAV NEC requires the person hold a required source rating per the NEC source rating requirement. The four UAV NECs are 8361, 8362, 8363, and 8364. These four NECs are described below.

a. 8361 Unmanned Aerial Vehicle (UAV) Systems Organizational Maintenance Technician

This person is responsible for performing organizational level maintenance on the UAV and its support systems. This NEC is open to anyone holding one of the following source rating codes:

- Aviation Electronic, Electrical and Computer Systems Technician (AT)
- Aviation Electrician's Mate (AE)
- Aviation Structural Mechanic (AM)
- Aviation Support Equipment Technician (AS)
- Naval Aircrewman Mechanical (AWF)
- Naval Aircrewman Avionics (AWV)

This NEC requires mandatory formal training and is open to pay grades of E3–E7.

[59] Ibid.

b. 8362 Unmanned Aerial Vehicle (UAV) External Pilot

This person is responsible for controlling launch and recovery of the UAV while in direct sight. This NEC is open to anyone holding one of the following source rating codes:

- Aviation Electronic, Electrical and Computer Systems Technician (AT)
- Aviation Electrician's Mate (AE)
- Aviation Structural Mechanic (AM)
- Aviation Support Equipment Technician (AS)
- Naval Aircrewman (Mechanical) (AWF)
- Naval Aircrewman (Avionics) (AWV)
- Naval Aircrewman (Operator) (AWO)
- Naval Aircrewman (Tactical Helicopter) (AWR)
- Naval Aircrewman (Helicopter) (AWS)

This NEC requires mandatory formal training and is open to pay grades E5–E6. Prior to arrival, a flight physical must be completed in accordance with aeromedical reference and waiver guide and also NAVMED P117. Additionally, a Class Two Aviation Flight Physical is required.

c. 8363 Unmanned Aerial Vehicle (UAV) Internal Pilot

This person is responsible for operating and navigating the UAV during the enroute, mission, and return phase of the flight. This NEC is open to anyone holding one of the following source rating codes:

- Aviation Electronic, Electrical and Computer Systems Technician (AT)
- Aviation Electrician's Mate (AE)
- Aviation Structural Mechanic (AM)
- Aviation Support Equipment Technician (AS)
- Naval Aircrewman (Mechanical) (AWF)
- Naval Aircrewman (Avionics) (AWV)
- Naval Aircrewman (Operator) (AWO)

- Naval Aircrewman (Tactical Helicopter) (AWR)
- Naval Aircrewman (Helicopter) (AWS)
- Aviation Maintenance Administration (AZ)

This NEC requires mandatory formal training and is open to pay grades E5–E6. Prior to arrival, a flight physical must be completed in accordance with aeromedical reference and waiver guide and also NAVMED P117. Additionally, a Class Two Aviation Flight Physical is required.

d. 8364 Unmanned Aerial Vehicle (UAV) Payload Operator

This person is responsible for operating the Electro-Optical/Infrared (EO/IR) UAV sensor during all phases of flight.

- Aviation Electronic, Electrical and Computer Systems Technician (AT)
- Aviation Electrician's Mate (AE)
- Aviation Structural Mechanic (AM)
- Aviation Support Equipment Technician (AS)
- Aviation Maintenance Administration (AZ)
- Intelligence Specialist (IS)

This NEC requires formal joint training at Fort Huachuca and is open to paygrades E5–E6.

2. UAV Source Rating Descriptions

a. AT—Aviation electronic, Electrical and Computer Systems Technician:

ATs perform organizational level maintenance on aircraft electronics systems, to include: communications, radar, navigation, Anti-Submarine warfare sensors, electronic warfare, data link, fire control, and tactical displays with associated equipment.[60]

[60] U.S. Navy, *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards*, AT-3I

b. AE—Aviation Electrician's Mate:

AEs maintain electrical and instrument systems, including power generation, conversion and distribution systems, aircraft batteries, interior and exterior lighting, and electrical control of aircraft systems, including hydraulics, landing gear, flight control, utility and power plant engine, flight and non-instrument-type indicating and warning systems, automatic flight control and stabilization systems, aircraft compass systems, attitude reference systems, and inertial navigation systems.[61]

c. AM—Aviation Structural Mechanic—Hydraulics:

AMs maintain aircraft airframe and structural components, flight surfaces and controls, hydraulic and pneumatic control, actuating systems and mechanisms, landing gear systems, and other utility systems. They fabricate and repair metallic and nonmetallic materials; supervise operation of airframe work centers; maintain aircraft metallic and non-metallic structures including fuselages, fixed and moveable flight surfaces, tail booms, doors, panels, decks, empennages, and seats (except ejection seats), flight controls and related mechanisms, hydraulic power storage and distribution systems including main (primary and secondary), auxiliary (utility), and emergency systems, hydraulic actuating subsystems, landing gear systems including wheels and tires, brakes, and emergency systems, pneumatic power, storage and distribution systems, hoists and winches, wing and tail fold systems, launch and arresting gear systems, hydraulic component repair and test; perform aircraft daily, special, hourly, and conditional inspections.[62]

d. AS—Aviation Support Equipment Technician:

ASs perform preventive and corrective maintenance on aviation support equipment, aviation armament handling equipment, aviation mobile firefighting units, and associated components and systems; service, inspect, test, troubleshoot, and repair gasoline and diesel engine systems, transmission systems, hydraulic, hydrostatic, and

[61] Ibid., AE-3

[62] Ibid., AM-3

pneumatic systems, steering and suspension systems, cryogenic systems, electrical systems, gas turbine compressor units, electrical and hydraulic power generating equipment, and air-conditioning and refrigeration systems (excluding avionics support equipment). They manage support equipment assets at different command levels, and provide training in operation of aviation support equipment.[63]

e. AWF—Naval Aircrewman (Mechanical):

AWFs are members of a fixed wing integrated tactical crew aboard C-2, C-9, C-12, C-20, C-37, C-40, C-130, E-6, and P-3 aircraft. They perform primary in-flight and ground duties as aircraft Flight Engineer/Crew Chief, Loadmaster, Reel Operator, Aircrew Readiness Manager. They also perform aircraft maintenance, weight and balance (W&B) calculations, aircraft systems rigging, Aircrew administration, Flight/Ground training, cargo movement, Medical Evacuations (MEDEVAC), passenger transport, small arms and Joint Special Warfare operations as well as contributing directly to operations for the purposes of attaining and maintaining the squadron's aircrew qualifications and certifications, knowledge of all aircraft systems, passenger and cargo handling, safety procedures and equipment, federal and military regulations for passenger transport, emergency procedures, and aircraft equipment.[64]

f. (U.S. Navy 2011aAW-3F)AWV—Naval Aircrewman (Avionics):

AWVs are members of a fixed wing integrated tactical aircrew aboard maritime patrol and reconnaissance, and command and control aircraft. They are knowledgeable of all avionics systems, safety equipment, emergency procedures, and aircraft equipment. They have primary in-flight and ground positions such as aircraft in-flight technicians, Electronic intelligence (ELINT) specialists, and airborne communicators, who maintain and operate aircraft systems; pilot and maintain Unmanned Aerial Vehicles (UAV), operate aerial photographic equipment; perform

[63] Ibid., AS-3

[64] Ibid., AW-3F

aircrew administration, flight and ground training, ordnance handling duties, joint special warfare operations, and Communications Material Security (CMS) handling.[65]

g. AWO—Naval Aircrewman (Operator):

AOs produce intelligence products for aircrews in support of operations and tactical missions worldwide; detect, analyze, classify, and track surface and subsurface contacts; operate an advanced sonar system utilizing sonobouys, radar, Electronic Support Measures (ESM), Magnetic Anomaly Detector (MAD), Identification Friend or Foe/Selective Identification Feature (IFF/SIF), and Infrared Detector (IR); perform aircrew duties that support mission planning, classified material handling, and training; and handle ordnance, inspect acoustic station equipment, and operate mission equipment such as: advanced imaging multi-spectral sensors, radar for safety of flight, and hand-held cameras.[66]

h. AWR—Naval Aircrewman (Tactical Helicopter):

AWRs detect, analyze, classify, and track sub-surface contacts; perform sonar and sonobuoy operations, help coordinate tactical communications relay; conduct weapons delivery in support of tactical missions; contribute directly to aircrew operations and Naval Special Warfare (NSW) missions, to include: Search and Rescue (SAR), Combat Search and Rescue (CSAR), Night Vision Device (NVD) operations, navigation, passenger and cargo transport, Vertical Replenishment (VERTREP), Medical Evacuations (MEDEVAC), crewserved weapons employment; perform observer duties for safety of flight; and contribute directly to aircrew operations, training, and administration.[67]

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[65] Ibid., AW-4(V)

[66] Ibid., AW-4(O)

[67] Ibid., AW-4(R)

i. AWS—Naval Aircrewman (Helicopter):

AWSs are members of multi-mission helicopter integrated tactical crews; perform Search And Rescue (SAR) operations, Airborne Mine Countermeasure (AMCM) operations utilizing sonar, magnetic, mechanical, and acoustic mine sweeping systems and logistics support; perform aircrew operations administration, flight and ground training, internal and external cargo movement, Medical Evacuations (MEDEVAC), passenger transport, aerial gunnery, small arms handling, Naval Special Warfare (NSW) insertion and extraction operations, Vertical Replenishment (VERTREP), and Night Vision Device (NVD) operations; and conduct observer duties for safety of flight.[68]

j. AZ—Aviation Maintenance Administration:

AZs perform technical, managerial, and support duties required by the Naval Aviation Maintenance Program (NAMP). They prepare aircraft and maintenance related correspondence; maintain directive control and custody records, control forms and reporting requirements; maintain files on departmental organization, manning, personnel travel, transfers, and training requirements; plan, program, and coordinate scheduled and unscheduled maintenance tasks and the incorporation of changes and modifications on/to aircraft and aeronautical equipment and support equipment; coordinate squadron/activity maintenance reporting requirements and recommend changes to maintenance policies and procedures; organize, maintain, and operate Navy Aeronautical Technical Publications Library (ATPL); oversee dispersed libraries; audit and train dispersed librarians; operate the Naval Aviation Logistics Command Management Information System (NALCOMIS); input, verify, and validate data pertaining to the history, operation, maintenance, configuration, receipt, and transfer of naval aircraft, related aeronautical equipment, and components installed in those equipment; maintain operations department flight data historical files and aviator data; setup and administer basic Local Area Networks (LAN) in support of detachment processing; liaise with ship and/or shore Information Technology personnel for LAN support for NALCOMIS; maintain data integrity between operations and maintenance departments; manage NALCOMIS

[68] Ibid., AW-3(S)

hardware and software upgrades; provide support and assistance to organizational, intermediate, and depot maintenance staff areas.[69]

k. IS—Intelligence Specialists:

ISs assist in every phase of the planning, collection, processing, analysis, and dissemination of intelligence information. They assemble and analyze multi-source operational intelligence in support of all warfare areas; assist in support of intelligence briefings, reporting, and analytical programs; prepare and present intelligence briefings; prepare material for use in mission planning; prepare graphics (annotated photographs, plot sheets, mosaics, overlays, etc.); plot and prepare multi-sensor imagery; draft intelligence reports; provide input to and receive data from computerized intelligence systems, ashore and afloat; and maintain intelligence files (photographs, maps, charts, photographic interpretation keys, etc.) and libraries.[70]

E. CONCEPT FOR DEVELOPMENT OF MANPOWER STRUCTURE FOR UAV INTEGRATION

1. Submarine Launched UAV Operator Requirement

Two possible UAVs are available to be launched and controlled from a submarine, ScanEagle and Switchblade. The prelaunch requirements for ScanEagle involve conducting continuity checks through mated connections on the missile tube. For Switchblade this requires loading it into the trash disposal unit and following launch procedure. Each of these UAVs when launched from a submarine requires the same set of operators. The operation team consists of a pilot and payload operator to observe the input from the camera or payload area. The launch team is responsible for ensuring the UAV is ready for deployment.

The pilot is required for the initial checks to verify proper operation and if the search or reconnaissance track requires changing once launched. This requirement is

[69] Ibid., AZ-3

[70] Ibid., IS-3

driven by the fact that both submarine capable UAVs are global positioning system (GPS) waypoint driven. After launch the UAV will fly on a predetermined GPS track that has been assigned prior to launch. The path or track may be changed by adding, deleting, or altering existing waypoints.

The payload operator is responsible for operating and/or observing the UAV's sensors. When in use, the UAV's payload should be monitored to ensure any information or intelligence in the area may be observed and recorded. The data is sent back to the submarine via radio frequency and displayed on the Fire Control Technician of the Watch's monitor.

1. Comparison of UAV Source Ratings to Submarine Ratings

a. Eligibility Requirements Description

Eligibility to obtain all four of these NECs is applicable to only four of the source ratings mentioned above AT, AE, AM, and AS. Additionally, AZ was eligible in the NECs that are pertinent to submarine operators. Comparison will be restricted to these four source ratings since they are eligible to obtain all four NECs as well as AZ. AWF, AWO, AWR, AWS, and AWV are not used for comparison because of their specific job descriptions. Acceptance to a source rating requires the candidate to meet a minimum Armed Service Vocational Aptitude Battery Test composite score (ASVAB). The U.S. Navy uses different subtest scores from the ASVAB to determine eligibility for a source rating. The subtest scores are shown in Table 2.

Table 2. ASVAB Subtest Composites Categories

Category	**Abbreviation**
General Science	GS
Arithmetic Reasoning	AR
Word Knowledge	WK
Paragraph Comprehension	PC
Numerical Operations	NO
Coding Speed	CS
Auto & Shop Information	AS
Mathematics Knowledge	MK
Mechanical Comprehension	MC
Electronics Information	EI
Sum of Word Knowledge & Paragraph Comprehension	VE
Assembly of Objects	AO

2. Comparable Submarine Ratings

Based on the aviation rating descriptions discussed, similar ratings must be found for comparison for UAV operations onboard a submarine. The five rates used for comparison are Aviation Electronics Technician (AT), Aviation Electrician's Mate (AE), Aviation Structural Mechanic (AM) Aviation Support Equipment Technician (AS), and Aviation Maintenance Administration (AZ).

Submarine crews have four source ratings which are comparable to AT, they are Electronics Technician (ET), Fire Control Technician (FT), Missile Technician (MT), and Sonar Technician Submarine (STS). Source rating descriptions for these are:

a. ET—Electronics Technician

They perform, manage, and supervise preventive and corrective maintenance on electronic equipment; and maintain, repair, calibrate, tune, and adjust electronic equipment utilizing test equipment and technical drawings for Command,

Control, Computer, Communication, and Intelligence (C4I) systems, cryptographic systems, radar systems, and navigation systems.[71]

b. FT—Fire Control Technician

They perform organizational and intermediate level maintenance on submarine combat control systems equipment, and associated combat control systems test equipment; operate submarine combat control systems; test submarine combat control systems; operate and maintain combat control systems associated systems; participate in weapons handling functions; and operate and maintain non-tactical computer systems and peripherals.[72]

c. MT—Missile Technician

They perform organizational and intermediate level maintenance on the Strategic Weapons System (SWS) on Ballistic Missile Submarines (SSBN) or the Attack Weapons System (AWS) on Guided Missile Submarines (SSGN); operate and maintain ballistic missile fire control systems, guidance subsystems, associated guidance subsystem test equipment, and missile and launcher/tube groups, along with all ancillary equipment; operate and perform maintenance on SWS and AWS systems; and operate, test, and repair associated ship/weapon subsystem test equipment and test and handling equipment.[73]

d. STS—Sonar Technician Submarine

They operate (control, evaluate, and interpret data) submarine sonar, oceanographic equipment, and submarine auxiliary sonar; coordinate submarine sonar and underwater fire control interface; perform organizational and intermediate maintenance on submarine and allied equipment.[74]

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[71] Ibid., ET-3

[72] Ibid., FT-3

[73] Ibid., MT-3

[74] Ibid., STS-3

Submarine crews have one source rating which compares with AE, Electrician's Mates (Nuclear) (EM(NUC)). Source rating description is:

e. EM(NUC)—Electrician's Mate (Nuclear)

They stand watch on generators, switchboards, control equipment, electrical equipment and shutdown reactor plants; operate and perform organizational and intermediate maintenance on power and lighting circuits, electrical fixtures, motors, generators, voltage and frequency regulators, controllers, distribution switchboards, and other electrical equipment; test for short circuits, grounds or other casualties; and rebuild electrical equipment, including solid state circuitry elements in an electrical shop.[75]

Submarine crews have two ratings which are comparable to AM and AS, Machinist's Mate Submarines (MM(ss)) and Machinist's Mate (Weapons) (MMW). Source rating descriptions are:

f. MM (SS)—Machinist's Mate (Submarines)

They operate, maintain, and repair (organizational and intermediate level) ship propulsion machinery, auxiliary equipment, and outside machinery, such as: steering engine, hoisting machinery, food preparation equipment, refrigeration and air conditioning equipment, windlasses, elevators, and laundry equipment; operate and maintain (organizational and intermediate level) marine boilers, pumps, forced draft blowers, and heat exchangers; perform tests, transfers, and inventory of lubricating oils, fuels, and water; maintain records and reports; and generate and stow industrial gases.[76]

g. MMW—Machinist's Mate (Weapons)

They perform organizational and intermediate level maintenance on test equipment, launching/firing systems, and stowage facilities associated with underwater ordnance, to include hydraulic systems, air systems, and seawater systems associated with launching/firing systems; perform organizational maintenance on underwater

[75] Ibid., EM-4(N)

[76] Ibid., MM-3

ordnance, small arms, and ammunition; prepare underwater ordnance for launching to include conducting post fire and post run routines; and perform operations and organizational maintenance on submarine anchoring systems.[77]

Submarine crews have two ratings which are comparable to AZ, Logistics Specialists (LS) and Yeoman (YN). Source rating descriptions are:

h. LS (SS)—Logistics Specialists (Submarines)

They provide diverse logistics and accounting support in a global setting to aviation, surface, subsurface, and expeditionary forces; order, receive, inspect, stow, preserve, package, ship, and issue materials and cargo; operate Navy post offices; account for government materials; and prepare and maintain required forms, records, correspondence, reports, and files.[78]

i. YN—Yeoman (Submarine)

They perform clerical and personnel security and general administrative duties, including typing and filing; prepare and route correspondence and reports; maintain records, publications, and service records; counsel office personnel on administrative matters; perform administrative support for shipboard legal proceedings and maintain shipboard legal files; conduct reporting/detaching and required retention related interviews; prepare and maintain personnel security documents and perform other personnel related functions; and serve as office managers.[79]

Comparison for acceptance into rating "A" Schools are shown in Table 3.

[77] Ibid., MM-3(W)

[78] Ibid., LS-3

[79] Ibid., YN-3

Table 3. Source Rating Entry Requirements[80]

	Requirements			
Source Rating	**Normal Color Perception**	**Security Clearance Eligible**	**U.S. Citizen**	**ASVAB Composite Score**
AE, AT, ET, FT, MT, STS	X	X	X	AR+MK+EI+GS=222 or VE+AR+MK+MC=222
EM(NUC)	X	X	X	AR+MK+EI+GS=252 or VE+AR+MK+MC=252
AM, AS	X			VE+AR+MK+AS=210 or VE+AR+MK+MC=210
MM(SS), MMW	X	X	X	VE+AR+MK+MC=210
AZ		X	X	VE+AR=103
LS(SS), YN(SS)	X Note 1	X	X	AR+MK+EI+GS=200 or VE+AR+MK+MC=200

Note 1: Normal color perception is waiverable for YN(SS)

F. ANALYSIS OF MANPOWER STRUCTURE

1. Mission Watchbill Organization

During submarine missions, watchbill manning and organization is at a premium. There are three officers on watch: the Officer of the Deck (OOD), Junior Officer of the Deck (JOOD), and the Junior Officer of the Watch (JOOW). All three officers are qualified periscope operators and have the skills necessary to recognize and analyze contacts viewed in the periscope.

Also in control, is a Fire Control Technician of the Watch (FTOW) and his assistant. The FTOW is responsible for entering and analyzing sonar and periscope

[80] Department of the Navy, *Military Personnel Manual* (Washington D.C.: Department of the Navy, 2010).

information to properly track contact movements. Generally, if there is a certain contact of interest, the FTOW will focus primarily on that contact while the assistant will help maintain the secondary contact picture.

Submarine missions require the crew to be dynamic and trained on many different jobs. During these critical missions when tracking a contact of interest, it is necessary to have two engine room watchstanders. The Engineroom Supervisor (ERS), and the Auxillary Electrician Aft (AEA) have the ability, with Commanding Officer's permission, to come to control for watchsection tracking duties. These two watchstanders are generally only employed when it is necessary to contacts at depth or in a heavy contact density environment.

2. Switchblade Manpower Requirements

a. Pre-launch

During this phase of operations, the required operating environment requires assessing to determine the required flight path. This process may be done very early if there is a known area of uncertainty near the required operating area. The evaluation of waypoints would be done by the on-watch team, to include overall guidance and input from the Commanding and Executive Officers. Once determined, the required GPS waypoints need to be entered into the Fire Control system for communication to the UAV. This step of the evolution could be done by the off-going Fire Control Technician of the Watch (FTOW).

The Switchbalde UAV is housed in the deployable canister that is launched from the trash disposal unit (TDU). The TDU evolution, while underway, is performed by the off-going Chief of the Watch (COW) or a qualified Culinary Specialists (CS) E6 or above, as the person in charge, along with the off-going Auxillaryman of the watch. The TDU evolution takes about 30 minutes of preparation time for pre-watch briefs, taking stations, obtaining permissions, and loading the TDU. During this phase of the evolution, the ship’s watchteam will establish periscope depth for UAV operations.

b. Launch and Operation

Once submarine parameters are established and permissions are obtained Switchblade is launched. This part of TDU operations takes approximately 15 minutes to complete. During launching and operation of the Switchblade, there are two critical personnel; the pilot and payload operator. The pilot's initial duties require verification that the UAV is flying normally, and on the proper preloaded track. After these initial flight checks are complete the pilot has no other duties unless the course change is required. Course changes are accomplished either by dragging and dropping preloaded waypoints to a new location or entering a new set of GPS coordinates into the fire control system based on the change in operating environment. System design makes altering the Switchblade's course a very simple and quick process.

c. Disposal

The Switchblade UAV is a very small and inexpensive tool. Based on the low cost and short flying time it is typically crashed into the water at a maximum speed to ensure destruction. When the track is determined, all environmental conditions are considered, and the last waypoint will be to an area of lowest activity where the UAV will be programmed to crash and destroy itself. This allows for the submarine to operate independently with no need for another asset for UAV recovery or for the submarine to surface to facilitate recovery.

3. ScanEagle

a. Pre-Launch

The ability to launch and operate the ScanEagle only applies to an SSGN class of submarine. Preparations for launch require the planning of the course to be flown via GPS waypoints, a prewatch brief, establishing submarine parameters and obtaining permission to conduct the evolution. With the launching evolution requiring the operation of a missile tube, a Condition 1 watchbill is required in Control, the Missile Control Center, and the missile compartment.

This watchbill ensures the required personnel to safely and efficiently operate all systems necessary for deployment of ScanEagle.

b. Launch and Operation

Once parameters are established and permissions are obtained, ScanEagle is launched. This process takes about 15–25 minutes to launch the UAV and restore the ship to a normal condition. Next, the submarine must proceed to periscope depth to assume control of the inflight ScanEagle. Once at periscope depth, the pilot will verify proper operation and flight path. If a course needs to be altered or changed, waypoints can be repositioned or new GPS coordinates can be entered for a new flight path by the pilot. The payload operator will verify that all assets are functioning properly and the UAV will fly the predetermined mission.

c. Recovery

Once the mission is complete, ScanEagle must be recovered. Recovery is typically performed by a surface vessel using the Skyhook system, which involves a 50 foot tall pole and a rope. The key to this evolution is the ability of the submarine to effectively communicate and turn control of the UAV over to the surface asset in the area. If there are no surface assets in the area, the submarine is required to either surface and attempt to catch the UAV, or crash it into the ocean. Due to the high cost of the UAV and the vulnerable position this places the submarine this option is not preferred.

V. SUMMARY, CONCLUSION AND RECOMMENDATIONS

A. SUMMARY

This research examined the manpower requirements for incorporating unmanned aerial vehicles (UAVs), specifically Switchblade and ScanEagle onboard four different classes of submarines. The examination provided a framework of multiple submarine specific ratings eligible and qualified for UAV operator training and operation. Furthermore, research showed that based on the simplicity of operation of Switchblade and ScanEagle, that no additional manpower requirements are necessary. Specifically, on all classes of submarines, Switchblade can be launched and flown with no additional watchstations manned, compared to a standard mission watchbill. Also, with ScanEagle, SSGN class submarines require no additional watchstanders once the UAV is launched, and airborne than would be required for a normal mission watchbill.

B. CONCLUSIONS AND RECOMMENDATIONS

1. Primary Research Question

- What are the manpower requirements associated with deployment, operations, recovery and maintenance of UAVs onboard SSN/SSGN's?

2. Conclusion

The manpower requirements for Switchblade deployment, operations, recovery and maintenance require no different personnel than are currently required for conducting trash disposal unit (TDU) operations and manning a normal mission watchbill. The manpower requirements for ScanEagle deployment, operations, recovery and maintenance are no different than those required to launch a Tomahawk missile. For both UAV operations quantitatively the personnel are the same with some qualitative changes. The required Navy Enlisted Classification (NEC) code required for UAV operation is only eligible for certain aviation specific ratings. While all of the eligible ratings are attached to an air squadron, one rate in particular, the Aviation Maintenance

Administration (AZ) rating has no direct duty onboard an air frame. While there are four available NECs, only two of them are pertinent for submarine UAV operators.

3. Recommendation:

- N87 modify the Navy Enlisted Manpower and Personnel Classifications & Occupational Standards to create submarine ratings specific UAV NECs for the following ratings: Electrician's Mate (NUC) (EM(NUC)), Electronics Technician (ET), Fire Control Technician (FT), Logistics Specialists (Submarines) (LS(SS)), Machinist's Mate (Submarine) (MM(SS)), Machinist's Mate Weapons (MMW), Missile Technician (MT), Sonar Technician Submarine (STS), Yeoman (Submarine) (YN(SS)).
- N87 incorporate UAV operations into the FT A-school training pipeline to aid the submarine in having operators with required NECs.
- Based on the simplicity of Switchblade and ScanEagle operations; Naval Education and Training Center develop two, one-week schools one on each coast, to allow submarine commands to send personnel in eligible ratings that affords the boat the most flexibility in mission watchbill management.
- Naval Education and Training Center create an the job training program, specifically, to create flexibility for potential changing of payloads that will be used.

C. AREAS FOR FURTHER STUDY AND RESEARCH

- Naval Education and Training Center conduct a study to examine optional locations for training facilities. The study should analyze if current infrastructure is adequate or capable of providing the quantity and quality of training required.

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